# PATENT SPECIFICATION

(11) 1 334 123

DRAWINGS ATTACHED

1 334 123

(21) Application No. 23284/71 (22) Filed 19 April 1971

(19)

(31) Convention Application No. P 20 18 799.9

(32) Filed 20 April 1970 in

(33) Germany (DT)

(44) Complete Specification published 17 Oct. 1973

(51) International Classification G01S 3/78

(52) Index at acceptance

H4D 716 735 750 751 756 776 783

## (54) DEVICE FOR LOCATING AND TRACKING AERIAL TARGETS

(71) We, VEREINIGTE FLUGTECHNISCHE WERKE-FOKKER G.m.b.H., of Hünefeldstrasse 1—5, 28 Bremen 1, Federal Republic of Germany, a German Body Corporate, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to a device for locating and tracking aerial targets with a laser beam which is radiated from a laser source and which, on detecting the aerial target, conveys information regarding the position and the movement of the target to the device by reflection.

The repelling of aerial targets requires knowledge of the particular position and of the movement in order to initiate counter measures. It is known to obtain the necessary information regarding an aerial target by means of radar equipment, either from a ground station or from a guided missile fired at the aerial target. In obtaining such information, the fact is used that electromagnetic rays of a corresponding wavelength are reflected from aerial targets. The data thus obtained regarding the position and movement may be supplied, for example, to an auto-pilot on a guided missile fired at the aerial target, which sets the direction-controlling surfaces accordingly.

In order to find the direction of the target, it is further known to use a radar method wherein the aerial lobe executes a precession movement, a so-called conical scan movement. With this radar process, a periodic fluctuation in the reflected energy occurs unless the target is on the axis of precession. In this case, the amplitude and the phase position of this periodic fluctuation form a measure of the angular deviation of the aerial target from the axis of precession of the aerial lobe.

Radar location methods are very expensive, however, because large aerial systems are necessary for adequate beaming of the energy to be transmitted and for the reliable detection of the reflected energy. This is a major disadvantage, particularly when the radar equipment is on board a guided missile where the diameter of the receiving aerial frequently determines the diameter of the guided missile. A further disadvantage is the considerable expense of the electronic circuits for analysing the direction information, and this fact is of great importance, particularly in installations on board guided missiles because such installations are only used once.

Another method of target location uses the heat rays which are radiated from an aerial target, particularly the heat rays from engines of an aerial target. This method is a passive method and is less expensive in comparison with the active method of radar location, but can only be used to a limited extent. The reason lies in the fact that the high-temperature points are generally situated at the rear of the aerial targets, namely at the exits from the engines. Thus an effective location can practically only be carried out from the rear of an aerial target. This is a serious disadvantage, however, which greatly increases the difficulty of repelling an aerial target. A further disadvantage is the fact that this passive method can only be used in fine weather.

Apart from the methods already described, a method is also known which uses a laser beam. This laser beam is transmitted continuously from a laser source and interrupted, for example by means of a rotating slotted disc. The spacing of the interruptions can be varied over the radius of the slotted disc. An important disadvantage of this method is the high energy consumption of the laser source for the continuous radiation of the laser beam. Furthermore, with a continuous laser beam, the target must be considerably smaller than the width of the laser beam. This means that for large aerial targets, a considerably large lobe would be necessary, so that for this reason alone, location of aerial targets with continuous laser beams becomes very expensive.

The present invention aims to avoid the

disadvantages outlined in a laser-beam method for the location and tracking of aerial targets.

According to the invention, there is provided a device for locating and tracking aerial targets with a laser beam which is radiated from a laser source and which, when an aerial target is detected, supplies information regarding the position and movement of the target to the device by reflection of the laser beam wherein the laser source radiates a focussed laser beam intermittently via a mirror whose angular position can be varied by means of an adjusting device so that the laser beam successively scans a solid predetermined angle.

By way of example, one embodiment of the invention will now be described with reference to the accompanying drawings, in which:—

Figure 1 shows a basic illustration of a device according to the invention; and

Figure 2 shows a graph.

In the basic illustration of Figure 1, a laser-beam source 10 is provided which emits laser-beam pulses 11. These laser-beam pulses 11 are thrown into a mirror 13 which deflects them substantially at right angles. On the way to the mirror 13, the laser-beam pulses pass through a further mirror 12 which is either semi-transmissive or is of smaller diameter than the laser beam. The mirror 12 is disposed at an angle of 45° to the direction of radiation of the emitted laser-beam pulses 11 and guides the reflected laser-beam pulses 11¹ into a receiver 19. The mirror 13 is periodically adjusted by means of a motor 14, the motor being controlled by a scan generator 15. The motor 14 and the scan generator 15 form an adjusting device 16 which is supplied with a control signal for the follow-up of the mirror 13, from an analysing circuit 17. The motor 14 adjusts the mirror 13 periodically so that the laser-beam pulses 11 emitted scan a fixed solid angle 18. Before the detection of the target, the mirror 13 executes the movement illustrated in Figure 2 and designated accordingly.

On detection of an aerial target, the laser-beam pulses 11 are reflected and conveyed to the receiver 19 by the mirror 12. The receiver 19 supplies the information to the analysing circuit 17 in which the direction information is obtained (as in a conventional radar installation) by comparison between the transmitted and the reflected radiation. From this, a control signal is produced in the analysing circuit 17 and is supplied to the adjusting device 16 for the follow-up of the mirror. The control signal is superimposed on the output signal from the scan generator 15 so that the motor 14 always readjusts the mirror 13 so that the mean beam direction always follows the aerial target detected. The circuit arrangement to provide such superimposition is shown in Fig. 1 by the encircled cross at the junction of scan generator 15 and analysing circuit 17 with the motor 14. The control signal from the analysing circuit 17 serves, at the same time, to switch over the swing 20 of the mirror so that, after an aerial target has been detected, the mirror 13 executes the movement represented in Figure 2 after the target detection. The representation in Figure 2 also shows that the scanning frequency is switched over to a higher value after the target detection; the control signal of the analysing circuit 17 is also used for this. Neither switching-over is illustrated in Figure 1.

Thus, in Figure 2, the waveform axis represents the centre axis of the solid angle scanned, which coincides with the mean position vector of the direction of radiation and is a straight line in the phase before the target detection i.e. in the target-detecting phase. After an aerial target has been detected, the axis of the solid angle follows the movements of the target because the mean position vector of the direction of radiation follows the aerial target. The variable axis in Figure 2 therefore coincides with the movements of the target detected and so indicates these movements.

Apart from the control signal, a further signal 21, which supplies information regarding the range of the aerial target detected, can be derived from the analysing circuit 17 for the control of an anti-aircraft weapon. This is possible without substantial additional expense.

Further information from additional devices may be supplied to the adjusting device 16, for example from optical radar equipment, by means of which it is possible to pre-direct the laser beam onto an aerial target to be detected. Excellent location and tracking of aerial targets is possible with the above-described exemplary device according to the invention, particularly in clear weather.

Utilisation of the above-described embodiment of the invention is based on a semi-active method which has the advantages of both the aforementioned active and passive methods, but not their disadvantages. A great advantage is the considerably less energy which is needed for the laser source because of the radiation of laser-beam pulses. In addition, the construction of the exemplary device according to the invention is considerably simpler and less expensive. Furthermore, an automatic follow-up of the mirror is provided for the tracking of an aerial target which has been detected so that the laser beam follows every movement of the aerial target detected. In addition, the solid angle is reduced after an aerial target

has been detected and the scanning frequency is increased; this means that an aerial target which has once been detected can no longer leave the angular range covered, even in the event of disturbances and certain flight manoeuvres.

WHAT WE CLAIM IS:—

1. A device for locating and tracking aerial targets with a laser beam which is radiated from a laser source and which, when an aerial target is detected, supplies information regarding the position and movement of the target to the device by reflection of the laser beam wherein the laser source radiates a focussed laser beam intermittently via a mirror whose angular position can be varied by means of an adjusting device so that the laser beam successively scans a solid predetermined angle.

2. A device as claimed in Claim 1, wherein, when an aerial target is detected, the reflected laser beam is deflected by a further mirror onto a receiver which supplies the information to an analysing circuit which conveys a control signal to the adjusting device for the follow-up of the first-mentioned mirror.

3. A device as claimed in Claim 2, wherein the control signal serves, at the same time, for switching over the adjusting device to provide a reduced swing of the first-mentioned mirror so that the laser beam is radiated with a reduced solid angle after an aerial target has been detected.

4. A device as claimed in Claim 2 or 3, wherein the control signal serves to switch over the adjusting device to provide a higher scanning frequency so that the laser beam scans the predetermined solid angle at an increased frequency after an aerial target has been detected.

5. A device as claimed in any one of claims 2 to 4, wherein a further signal is derived from the analysing circuit and supplies information regarding the range of the aerial target detected.

6. A device as claimed in any preceding claim, wherein additional devices are provided which supply information to the adjusting device whereby the laser beam is pre-directed onto an aerial target to be detected.

7. A device for locating and tracking aerial targets with a laser beam substantially as hereinbefore described with reference to the accompanying drawing.

For the Applicants:
J. F. WILLIAMS & CO.,
Chartered Patent Agents,
113 Kingsway,
London, W.C.2.

Printed for Her Majesty's Stationery Office by Burgess & Son (Abingdon), Ltd.—1973.
Published at The Patent Office, 25 Southampton Buildings, London WC2A 1AY
from which copies may be obtained.

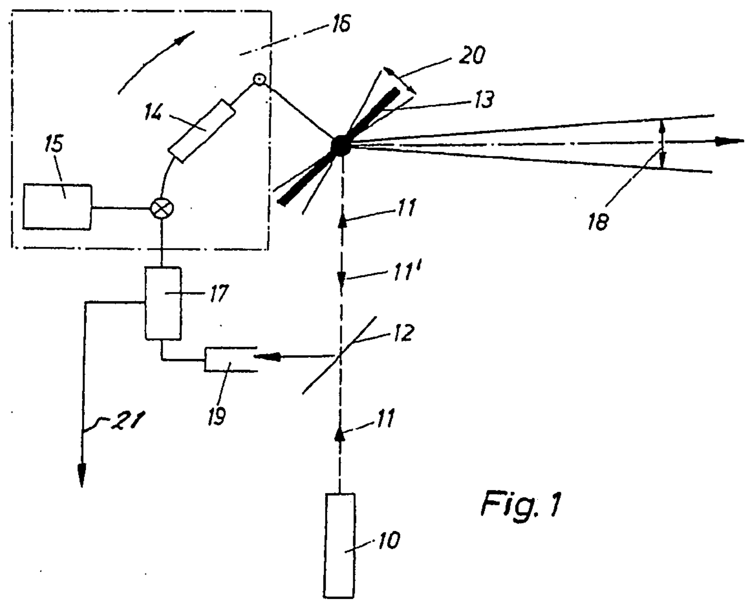
16
20
13
14
15
11
18
11'
17
12
21
19
11
10

Fig. 1

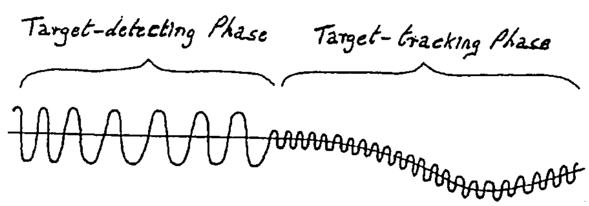
Target-detecting Phase
Target-tracking Phase

Fig. 2